# New for old

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# Chapter 1

**General introduction**

*"Adding life to years, not just more years to life!"*
*– The Gerontological Society of America*

## Ageing Society

The ageing of our society is becoming a more and more prominent topic in health care, research and politics nowadays. The percentage of older adults aged 65 years and over in The Netherlands was 27% in 2012, by 2040 this percentage will be 51% [1]. While people are reaching a higher age, the added years however often are compromised by chronic health conditions and decreasing fitness, debilitating one's independence and quality of life [2]. A prevalent condition compromising older adults' health and fitness is frailty, which affects about ten percent of the general older adult population [3]. A commonly used definition for this condition is proposed by Fried et al (2001); "a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss (10lbs in the past year), self-reported exhaustion, weakness (grip strength), slow walking speed and low physical activity" [4]. As indicated by the definition, frailty has widespread influence on physical functioning. It also severely heightens the risk for falls, disability, hospitalization and mortality [5]. Due to the ageing of society and prevalence of frailty among the ageing population, an important feature in healthcare research is to heighten the fitness, quality of life and eventually independence among (frail) older adults. It was commonly thought that deterioration of fitness is inevitable when ageing. However, research has shown that the downward spiral in ageing that is commonly feared is preventable, and even reversible [6]. Since fitness is one of the premises for health and independence, this creates a need to keep physical functioning up to par in later life.

## Prevention of physical decline

An important factor preventing decline in fitness is physical activity [6,7]. Previous research has shown that structured regular exercise can improve fitness in older adults [8], since there are mutual relationships between physical activity, fitness and health as illustrated in Figure 1 [9].

In ageing it is presumed that health deteriorates, due to on the one hand a less active life caused by for instance retirement and on the other hand the growing risk of degenerative diseases and wear-and-tear of body structures [9]. In response fitness, i.e. the ability to perform activities of daily life (ADL), is lowered. This causes a person's independence and quality of life to decrease. In stimulating physical activity, a person's fitness can be ameliorated. Enlarged fitness provides persons with a greater capability to perform their ADL and therefore to stay independent in their home life, which heightens quality of life [10]. Fitness comprises many physical aspects such as physical strength, balance, walking speed and cardiovascular functioning. These can be ameliorated by means of sufficient daily physical activity and training in older adults [11-13]. Sufficient daily physical activity in turn has preventive effects regarding health and for instance diabetes type II, coronary heart disease and osteoporosis and is known to reduce fall risk [14]. Training or daily physical activity do not have to concern very vigorous activities: merely thirty minutes per day





of low to moderate intensity activities such as walking or household chores can already provide noticeable positive differences in physical functioning. A small effort therefore provides relatively large gains on health.

To prevent physical decline, it is essential for older adults to be sufficiently physically active. However, older adults generally do not engage in sufficient daily physical activity to prevent physical decline [15]. In The Netherlands, merely 49.4-57.7% of older adults engage in the minimal amount of physical activity to stay healthy as described by the World Health Organization [16]. These guidelines recommend to perform at least a minimum of 30 min. five days a week of moderate-intensity aerobic physical activity to preserve fitness and health or a minimum of 20 min. three days a week of vigorous-intensity aerobic activity in order to improve fitness and health [16,17].



## Motivating older adults to be physically active

Multiple reasons can cause older adults to not be as active as ideally should be to stay fit and healthy, even though staying fit and healthy in older age is depicted as an important goal for most people. Barriers to being physically active that older adults often experience are practical barriers such as the inability to go to an exercise facility due to lack of transportation or physical inability, and psychological barriers such as fear of falling, the belief that exercise is not beneficial or even dangerous for them or the feeling that "exercising is not for older adults" [6]. Design of physical activity interventions for older adults should therefore address the barriers older adults often face in order to motivate them to adhere. A possible solution for multiple of these barriers can be found in the design of home-based exercise programs. Home-based programs can provide exercise opportunities while relieving practical barriers such as lack of transportation or exercise facilities in the older adult's neighborhood.

## Home-based exercise programs

Home-based exercise programs have demonstrated great use in ameliorating daily physical activity and physical performance in past research [18]. However, home-based independent training often suffers from low adherence since there is a lack of an incentive such as exercise group colleagues or a coach [15,19]. Especially in older adults that already do tend to be physically inactive, this lack of adherence is an important point to be addressed in design of home-based exercise programs. A possible solution can be found in remote coaching of participants by means of telephone or internet. Remote coaching allows subjects to train at their own time and place, while still offering the support and stimulation from an exercise trainer. In previous studies, remote coaching in home-based exercise programs has often been performed by telephone and is considered quite effective in raising adherence in home-based exercise programs [20]. Some efforts have been made to use web-based remote coaching, which were quite successful in raising subjects' motivation compared to control groups that did not use web-based remote coaching [21,22]. However, optimal design of web-based remote coaching strategies has yet to be further determined.

## Accurate remote measurement

A premise for effective remote coaching strategies in a home-based exercise program is insight into the subject's physical activity behavior, to allow the coaching to be tailored to the participant's needs. When exercising independently at home, a coach is generally not able to monitor adherence and progress unless the behavior is adequately monitored at the site. Body-worn sensors such as for instance pedometers, accelerometers or a combination of sensors can provide this monitoring. Accelerometers have been used in numerous occasions to measure gait and postures, and in many cases are accurate under laboratory circumstances [23]. Currently, efforts are made to transfer accurate laboratory measurement into accurate daily life measurement, which provides more challenges than standardized measurement under laboratory circumstances due to the variance in performance of activities in daily life [24]. By measuring gait and postures, daily physical activity could be estimated. When body-worn sensors can measure gait, postures and daily physical activity accurately and reliably and are unobtrusive and safe to the wearer regarding design and use, these sensors could be the key to supporting remote coaching in home-based exercise programs [25].

## Remote instructions

In recent studies remote administration of exercise by means of novel technology such as smartphones and tablet PC's has also been known to be effective in supporting home-based exercise programs. For instance, Bickmore et al. demonstrated a significantly higher increase in daily step count as measured by a step counter after two months of training using an automatic exercise coach on a tablet compared to a control group receiving training without tablet-based coaching [26]. Silveira et al. recently performed a pilot study with Active Lifestyle, a tablet-based system providing home-based training to enhance balance and strength. The application successfully enabled independent training at home and demonstrated high adherence and enthusiasm with its participants [22].

## Home-based exercise programs integrating novel technology

Based upon the abovementioned developments, a combination of body-worn sensors for daily physical activity monitoring, a tablet application for exercise instruction and remote contact with a coach seems like a good opportunity to allow older adults to successfully perform a personally tailored and coached exercise program at home to preserve and ameliorate their fitness and/or health. Nonetheless, providing older adults with novel technology such as tablets, smartphones and sensors is often met with skepticism, as the current generation of older adults often have no experience in working with computers or tablet PCs. Learning new skills at advanced age provides a steep learning curve, which is often discouraging to take up use of a new technology [27]. However, the percentage of persons aged 65 years and over that do own a tablet or smartphone has been rising steeply over the past years [27]. In 2014, 18% of US and 65% of Dutch older adults of 64 years and





over owned a tablet, and these percentages are expected to rise further in the coming decades since people of 45-65 years are more and more accustomed to using computers or tablets in their work life [28,29]. It is therefore a very timely effort to start designing tailored, effective home-based exercise programs for older adults using novel technology, an effort that was undertaken in the project providing the platform for this thesis.

## Aim and outline of the thesis

The main aim of this thesis is to develop a home-based exercise program for older adults stimulating daily physical activity and physical functioning that integrates remote coaching supported by a necklace-worn gait- and posture sensor and a tablet, and to evaluate its feasibility and effectiveness.



The research questions that therefore will be addressed in this thesis concern the optimal design of this home-based exercise program. Specific questions that will be addressed are:

- Is the home-based exercise program suitable for the selected target group?
- Is the home-based exercise program effective in increasing daily physical activity and ameliorating physical functioning?
- Is the set-up of the technology supporting the home-based exercise program suitable for stimulating daily physical activity and physical functioning?
- Is the behavioral strategy driving the intervention effective for stimulation of daily physical activity and physical functioning?

**Chapter 2** addresses a review of the literature regarding the different remote coaching strategies for home-based exercise programs for older adults that have been proposed in literature. A coaching strategy should be optimized in mode, content as well as frequency of contact to provide optimal stimulation to adhere for the participant. In **chapter 3** a tool to support remote coaching is validated for use in daily life of older adults: a necklace-worn gait- and posture sensor that can objectively assess physical activity. The objective data of the sensor can be used to provide coaches with accurate information of daily physical activity and adherence in participants. In **chapter 4** the design of a six-month cohort study integrating a home-based physical activity intervention for frail older adults supported by the necklace-worn sensor and a tablet is described, in which subjects are remotely coached to enhance adherence and effectiveness of the program. The feasibility and practical implications of this home-based exercise program as addressed in the cohort study described in chapter 4 are evaluated in **chapter 5**. In **chapter 6**, the effectiveness for increasing daily physical activity and physical functioning of the home-based exercise program is addressed. **Chapter 7** will address our target group selection, content of the exercise program, technologic performance and behavioral strategies behind the intervention in a general discussion. In addition, practical implications of the results in this thesis will be addressed as well as a critical reflection upon our results and recommendations for future research will be provided.

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